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For the President of the European Patent Office
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Title: "Integrated process for urea and melamine production"

DESCRIPTION

Technical Field

5 The present invention relates to a process for the integrated production of urea and melamine.

In particular, the present invention concerns a process of the above-identified type, wherein urea is produced in a urea plant comprising a high pressure urea synthesis section and a urea recovery section and wherein the off-gases resulting as by-products of the melamine synthesis
10 are recycled to said high pressure urea synthesis section.

In the following description and subsequent claims, with the expression "high pressure urea synthesis section" it is intended to mean a section operated at a pressure of at least about 120 bar, generally between 130-260 bar.

15 More in particular, the process according to the present invention is of the type wherein the off-gases to be recycled have a pressure of at least 2 bar, generally between 2 and 30 bar.

The present invention is also concerned with an integrated plant for carrying out such a process.

20 As is known, in the field of urea and melamine there is increasingly felt the need of providing integrated processes wherein the off-gases produced in the melamine synthesis can be efficiently exploited for urea production.

Prior Art

25 In order to meet the above requirement, integrated processes have been proposed, wherein melamine is produced in a plant, so called melamine plant, using - as raw materials (reactants) - NH₃ and urea, the latter being produced in a plant for urea production, so called urea plant, to which the off-gases coming from the melamine plant and substantially containing NH₃ and CO₂, are recycled as raw materials (reactants).

According to these processes, the off-gases, generally discharged from the melamine plant at a pressure comprised between 2 and 30 bar, are appropriately treated before being fed into the urea plant.

In particular, the off-gases are condensed, at a pressure equal or lower than their discharge pressure, with a weak ammonia aqueous solution (ammonia concentration comprised between 0 to 15% by weight). The so obtained off-gas liquid solution is then fed to a waste water treatment section of the urea plant, generally operated at a pressure of about 2-5 bar, where NH₃ and CO₂ are recovered from the aqueous solution and recycled to the high pressure urea synthesis section.

In the alternative, it has also been proposed to suitably compress the above off-gas liquid solution and recycle it directly to the high pressure synthesis section of the urea plant.

Although the above need is in some extent met by these processes, the latter are affected by several drawbacks.

In the first case, high energy consumption are required to separate NH₃ and CO₂ from the off-gas liquid solution in the waste water treatment section. Moreover, since the pressure in such a section is often much lower than the pressure of the off-gases discharged from the melamine plant, the off-gases have to be expanded before their condensation and recycle to the waste water treatment section of the urea plant, and thus there is also an energy waste in term of pressure loss.

In the second case, an additional, not negligible, amount of water is fed in the high pressure urea synthesis section through the recycled off-gas liquid solution. Since water is a by-product of the urea synthesis, its presence in the reactant feed is detrimental for the CO₂ conversion into urea. The urea conversion yield is thus negatively affected by the water contained in the recycled off-gas liquid solution with an ensuing increase in the energy consumption required to recover urea from the urea solution leaving the synthesis section and for recycling the unconverted reagents back to the synthesis section.

Summary of Invention

The technical problem underlying the present invention is to provide an integrated process for urea and melamine production having functional features such as to fully overcome the drawbacks set forth with respect to
5 the prior art, wherein urea is produced at higher conversion yield and with lower energy consumption.

The above problem is solved, according to the invention, by an integrated process for urea and melamine production, wherein urea is produced in a urea plant comprising a high pressure urea synthesis section and a urea recovery section for separating urea from a carbamate aqueous solution, and melamine is produced in a melamine plant wherein off-gases resulting as by-products of the melamine synthesis are discharged therefrom at a pressure of at least 2 bar and recycled to said high pressure urea synthesis section, the process being characterized in that it further
10 comprises the steps of:

- feeding said off-gases coming from said melamine plant to an off-gas condensation section preferably operating at substantially the same pressure of the off-gases;
- feeding said carbamate aqueous solution coming from said urea recovery section to said off-gas condensation section;
- condensing said off-gases with said carbamate aqueous solution in said off-gas condensation section obtaining a concentrated carbamate aqueous solution;
- feeding the so obtained concentrated carbamate aqueous solution to said
25 high pressure urea synthesis section.

In case the pressure of the carbamate aqueous solution leaving the urea recovery section is lower than the operating pressure of the off-gas condensation section, then the process according to the present invention advantageously further comprises the step of:
0 - compressing said carbamate aqueous solution coming from said urea recovery section to a pressure substantially corresponding to the operating pressure of said off-gas condensation section, previous to feeding it in such a section.

Moreover, in case the pressure of the off-gases discharged from the melamine plant is lower than the pressure of the urea synthesis section, then the process according to the present invention advantageously further comprises the step of:

5 - compressing said concentrated carbamate aqueous solution coming from said off-gas condensation section to a pressure substantially corresponding to the operating pressure of said high pressure urea synthesis section, previous to feeding it in such a section.

10 The main advantage resulting by the process according to the present invention is that condensation of the off-gases is performed by exploiting the low amount of water already contained in the carbamate aqueous solution obtained in the urea recovery section of the urea plant and which is anyway recycled to the high pressure urea synthesis section. Therefore, contrary to the processes of the prior art - no additional amount of water
15 is added to the off-gasses when recycling them from the melamine plant to the urea plant. It follows that, thanks to the invention, a more concentrated carbamate solution is recycled to the high pressure urea synthesis section of the urea plant with the consequence that the urea conversion yield is advantageously increased and the energy consumption
20 required for recovering urea and recycling the unconverted reagents to the synthesis section are advantageously substantially decreased.

Further characteristics and advantages of the invention will result from the following description of an embodiment thereof given by way of non limiting example with reference to the attached drawing.

25 Brief description of the drawing

- Figure 1 schematically shows an integrated plant for urea and melamine production according to the process of the present invention.

Detailed description of a preferred embodiment

With reference to the figure, with number 10 is generally and 0 schematically indicated an integrated plant for urea and melamine production according to the present invention. The integrated plant 10 comprises a plant 11 for the production of melamine and a plant 12 for

the production of urea

The melamine plant 11 of the present invention can be of the catalytic low pressure type (up to 70 bar) or of the non-catalytic high pressure type (above 70 bar), provided that the off-gases discharged from the melamine

5 plant have a pressure of at least 2 bar. The plant 11 comprises a low pressure or high pressure melamine synthesis section 13.

Preferably, but non exclusively, the melamine plant 12 is of the non-catalytic high pressure type, wherein the off-gases discharged as by-products of the melamine synthesis have a pressure comprised between 3
10 and 30 bar, preferably between 20 and 25 bar. Of course, the off-gases discharged from the melamine plant according to the present invention can also have a much higher pressure, depending on the pressure at which melamine is produced.

15 The urea plant 12 of the present invention is of the total recycle type, wherein urea is produced at a pressure of at least 120 bar, generally at about 130-260 bar, in a high pressure urea synthesis section 15 in fluid communication with a urea recovery section 16.

20 Generally, the urea recovery section 16 comprises (not shown) a medium pressure recovery section, operating at a pressure of about 15-30 bar and/or a low pressure recovering section, operating at a pressure of about
2-10 bar.

25 Preferably, the urea plant 12 is of the so called CO₂ or ammonia stripping type, with the high pressure urea synthesis section operated at about 130-170 bar and comprising at least one urea synthesis reactor, stripper and carbamate condenser (not shown), connected one to the other so as to form a substantially isobaric loop.

For instance, the urea plant 12 of the present invention is of the CO₂ stripping type and the urea recovery section 16 only includes the low pressure section.

0 According to an advantageous feature of the present invention, the integrated plant 10 further comprises an off-gas condensation section 17 arranged between the plant 11 for melamine production and the plant 12

for urea production and in fluid communication with the melamine synthesis section 13, the urea recovery section 16 and the high pressure synthesis section 15.

Moreover, depending on the pressure of the solutions leaving the urea recovery section 16 and the off-gas condensation section 17, respectively, the integrated plant 10 of the invention optionally further comprises a first compression section 18, arranged between and in fluid communication with the urea recovery section 16 and the off-gas condensation section 17, and a second compression section 19, arranged between and in fluid communication with the off-gas condensation section 17 and the high pressure urea synthesis section 15. Compression sections 18 and 19 generally comprise at least one compressor or pump (not shown) for liquid flow of the conventional type.

The operation of the integrated plant 10 according to the invention is described hereinbelow.

CO₂ and ammonia are fed to the high pressure urea synthesis section 15 of the urea plant 12 through flow line 30. Section 15 is also fed with a flow of concentrated carbamate aqueous solution, which will be described in greater details in the following description, through flow line 31.

In the high pressure urea synthesis section 15, the above reactants are made to react and a urea solution comprising urea, ammonium carbamate, free ammonia and water is obtained.

The urea solution leaves section 15 through flow line 32 and is fed to the urea recovery section 16, where it is further treated in order to separate urea from the other components of the solution (mainly water and unconverted reactants).

A concentrated urea solution, for instance comprising about 70% by weight of urea, is then discharged, through line 33, from the urea recovery section 16 and at least in part used as reactant in the plant 11 for melamine production.

To this aim, the concentrated urea solution, or a portion thereof, is fed, through line 34, to the melamine synthesis section 13. In the example of

figure 1, not all the urea produced is used for the melamine synthesis and thus a portion of the concentrated urea solution is fed, through line 35, to a concentration section (not shown) of the urea plant 12 for further urea purification in order to produce for instance urea prills or granules.

5 To control the melamine synthesis, section 13 can optionally also be fed with an additional flow of ammonia, indicated in figure 1 by flow line 14.

From the melamine synthesis section 13, a melamine solution is discharged, through line 36, for further processing such as cooling (not shown), where melamine is converted into a powder and exits the plant

10 11.

Moreover, CO₂ and NH₃ off-gases are also obtained in section 13, as by-products of the melamine synthesis and leaves section 13 through flow line 37. Generally, before leaving the melamine synthesis section 13, the off-gases are suitably washed (scrubbed), not shown, with the feed
15 concentrated urea solution in order to remove possible liquid melamine entrained in such gases.

Advantageously, the so obtained off-gases are then fed, through flow line 37, to the off-gas condensation section 17 of the integrated plant 10 of the present invention.

20 The off-gas condensation section 17 is further advantageously fed with an aqueous carbamate solution coming from the urea recovery section 16 of the urea plant 12, through a flow line 38.

This aqueous carbamate solution comprises at least part of the water and the unconverted reactants that have been separated from the urea
25 solution in the urea recovery section 16. In the field, such a solution is commonly called recycle carbamate solution since it is the solution that is recycled (suitably compressed) to the high pressure urea synthesis section. An example of composition of the aqueous carbamate solution according to the present invention comprises: 20-40% by weight of
30 ammonia, 20-40% by weight of CO₂ and the rest water. The amounts of these components can vary depending on the urea synthesis process.

Preferably, the off-gas condensation section 17 is operated at substantially

the same pressure as the pressure of the off-gases leaving the melamine synthesis section 13.

In case the pressure of the off-gases coming from the melamine synthesis section 13 is higher than the pressure of the aqueous carbamate solution

5. discharged from the urea recovery section 16, the latter is advantageously compressed in the compression section 18 to the pressure of such off-gases i.e. to the operating pressure of the off-gas condensation section 17.

In the off-gas condensation section 17, the off-gases are completely condensed (apart for a negligible amount of inert components non

10 condensable) in the aqueous carbamate solution thus advantageously obtaining a concentrated carbamate aqueous solution, which is recycled to the high pressure synthesis section 15 through flow line 31.

Should, as it is often the case, the operating pressure of the high pressure synthesis section 15 be higher than the operating pressure of the off-gas

15 condensation section 17, then the concentrated carbamate aqueous solution leaving such a condensation section 17 is advantageously compressed in the compression section 19 to the operating pressure of the urea synthesis section 15.

In integrated plant 10, the flow lines indicated in figure 1 by reference

20 signs 14, 30-38, schematically represent connecting ducts or pipes of conventional type.

The plant 10 described above is particularly suitable for carrying out the integrated process for urea and melamine production according to the present invention, wherein urea is produced in the urea plant 12

25 comprising the high pressure urea synthesis section 15 and the urea recovery section 16 for separating urea from a carbamate aqueous solution, and melamine is produced in the melamine plant 11 wherein off-gases resulting as by-products of the melamine synthesis are discharged therefrom at a pressure of at least 2 bar and recycled to said high pressure urea synthesis section 15, the process being characterized in that it further comprises the steps of:

- feeding said off-gases coming from said melamine plant 11 to the off-gas

condensation section 17 preferably operating at substantially the same pressure of the off-gases;

- feeding said carbamate aqueous solution coming from said urea recovery section 16 to said off-gas condensation section 17;
- 5 - condensing said off-gases with said carbamate aqueous solution in said off-gas condensation section 17 obtaining a concentrated carbamate aqueous solution; and
 - feeding the so obtained concentrated carbamate aqueous solution to said high pressure urea synthesis section 15.
- 10 According to another aspect of the invention, the present process can be suitable carried out also for the revamping or retrofitting of pre-existing urea and melamine plants as well as for the modification of pre-existing integrated plants for urea and melamine production.
- 15 In this case, and in addition to the advantages set forth above, it is worth noting that thanks to the present invention, and in particular to the feature of condensing the off-gases of the melamine plant with the carbamate aqueous solution discharged from the urea recovery section so as to obtain a concentrated carbamate aqueous solution, which is recycled to the high pressure urea synthesis section, it is not required to modify 20 the equipment of the pre-existing high pressure urea synthesis section, such as the high pressure synthesis reactor, stripper and condenser.
- 25 The invention thus conceived is susceptible to further embodiments and modifications all falling within the skill of the man skilled in the art and, as such, falling within the scope of protection of the invention itself, as it is defined by the following claims

CLAIMS

1. Integrated process for urea and melamine production, wherein urea is produced in a urea plant comprising a high pressure urea synthesis section and a urea recovery section for separating urea from a carbamate aqueous solution, and melamine is produced in a melamine plant wherein off-gases resulting as by-products of the melamine synthesis are discharged therefrom at a pressure of at least 2 bar and recycled to said high pressure urea synthesis section, the process being characterized in that it further comprises the steps of:
 - 5 10 - feeding said off-gases coming from said melamine plant to an off-gas condensation section;
 - feeding said carbamate aqueous solution coming from said urea recovery section to said off-gas condensation section;
 - condensing said off-gases with said carbamate aqueous solution in said off-gas condensation section obtaining a concentrated carbamate aqueous solution;
 - 15 - feeding the so obtained concentrated carbamate aqueous solution to said high pressure urea synthesis section.
2. Process according to claim 1, characterized in that said off-gas condensation section is operated at a pressure substantially equal to the pressure of said off-gases.
 - 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120 125 130 135 140 145 150 155 160 165 170 175 180 185 190 195 200 205 210 215 220 225 230 235 240 245 250 255 260 265 270 275 280 285 290 295 300 305 310 315 320 325 330 335 340 345 350 355 360 365 370 375 380 385 390 395 400 405 410 415 420 425 430 435 440 445 450 455 460 465 470 475 480 485 490 495 500 505 510 515 520 525 530 535 540 545 550 555 560 565 570 575 580 585 590 595 600 605 610 615 620 625 630 635 640 645 650 655 660 665 670 675 680 685 690 695 700 705 710 715 720 725 730 735 740 745 750 755 760 765 770 775 780 785 790 795 800 805 810 815 820 825 830 835 840 845 850 855 860 865 870 875 880 885 890 895 900 905 910 915 920 925 930 935 940 945 950 955 960 965 970 975 980 985 990 995 1000 1005 1010 1015 1020 1025 1030 1035 1040 1045 1050 1055 1060 1065 1070 1075 1080 1085 1090 1095 1100 1105 1110 1115 1120 1125 1130 1135 1140 1145 1150 1155 1160 1165 1170 1175 1180 1185 1190 1195 1200 1205 1210 1215 1220 1225 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5. Process according to claim 1, characterized in that said concentrated carbamate aqueous solution is directly fed to said high pressure urea synthesis section.
6. Process according to claim 1, characterized in that it further comprises
5 the step of:
 - compressing said concentrated carbamate aqueous solution coming from said off-gas condensation section to a pressure substantially corresponding to the operating pressure of said high pressure urea synthesis section, previous to feeding it in such a section.
- 10 7. Integrated plant for urea and melamine production, wherein urea is produced in a urea plant (12) comprising a high pressure urea synthesis section (15) and a urea recovery section (16) for separating urea from a carbamate aqueous solution, and melamine is produced in a melamine plant (11) comprising a melamine synthesis section (13) wherein off-gases
15 resulting as by-products of the melamine synthesis are discharged therefrom at a pressure of at least 2 bar and recycled to said high pressure urea synthesis section (15), the plant being characterized in that it further comprises:
 - an off-gas condensation section (17) arranged between said the plant (11) for melamine production and said plant (12) for urea production and in fluid communication with said melamine synthesis section (13), said urea recovery section (16) and said high pressure synthesis section (15).
 - connecting means (37) for feeding said off-gases coming from said melamine synthesis section (13) to said off-gas condensation section (17);
 - connecting means (38) for feeding said carbamate aqueous solution coming from said urea recovery section (16) to said off-gas condensation section (17), wherein said off-gases are condensed with said carbamate aqueous solution obtaining a concentrated carbamate aqueous solution;
 - connecting means (31) for feeding the so obtained concentrated carbamate aqueous solution to said high pressure urea synthesis section (15).

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8. Plant according to claim 7, characterized in that it further comprises a first compressor section (18), arranged between and in fluid communication with said urea recovery section (16) and said off-gas condensation section (17) for compressing said carbamate aqueous

5 solution coming from said urea recovery section (15) to a pressure substantially corresponding to the operating pressure of said off-gas condensation section (17).

9. Plant according to claim 7, characterized in that it further comprises a second compression section (19), arranged between and in fluid

10 communication with said off-gas condensation section (17) and said high pressure urea synthesis section (15) for compressing said concentrated carbamate aqueous solution coming from said off-gas condensation section (17) to a pressure substantially corresponding to the operating pressure of said high pressure urea synthesis section (15).

15

ABSTRACT

In an integrated process for urea and melamine production, urea is produced in a urea plant (12) comprising a high pressure urea synthesis section (15) and a urea recovery section (16) for separating urea from a carbamate aqueous solution, and melamine is produced in a melamine plant (11) wherein off-gases resulting as by-products of the melamine synthesis are discharged therefrom at a pressure of at least 2 bar and recycled to the high pressure urea synthesis section (15).
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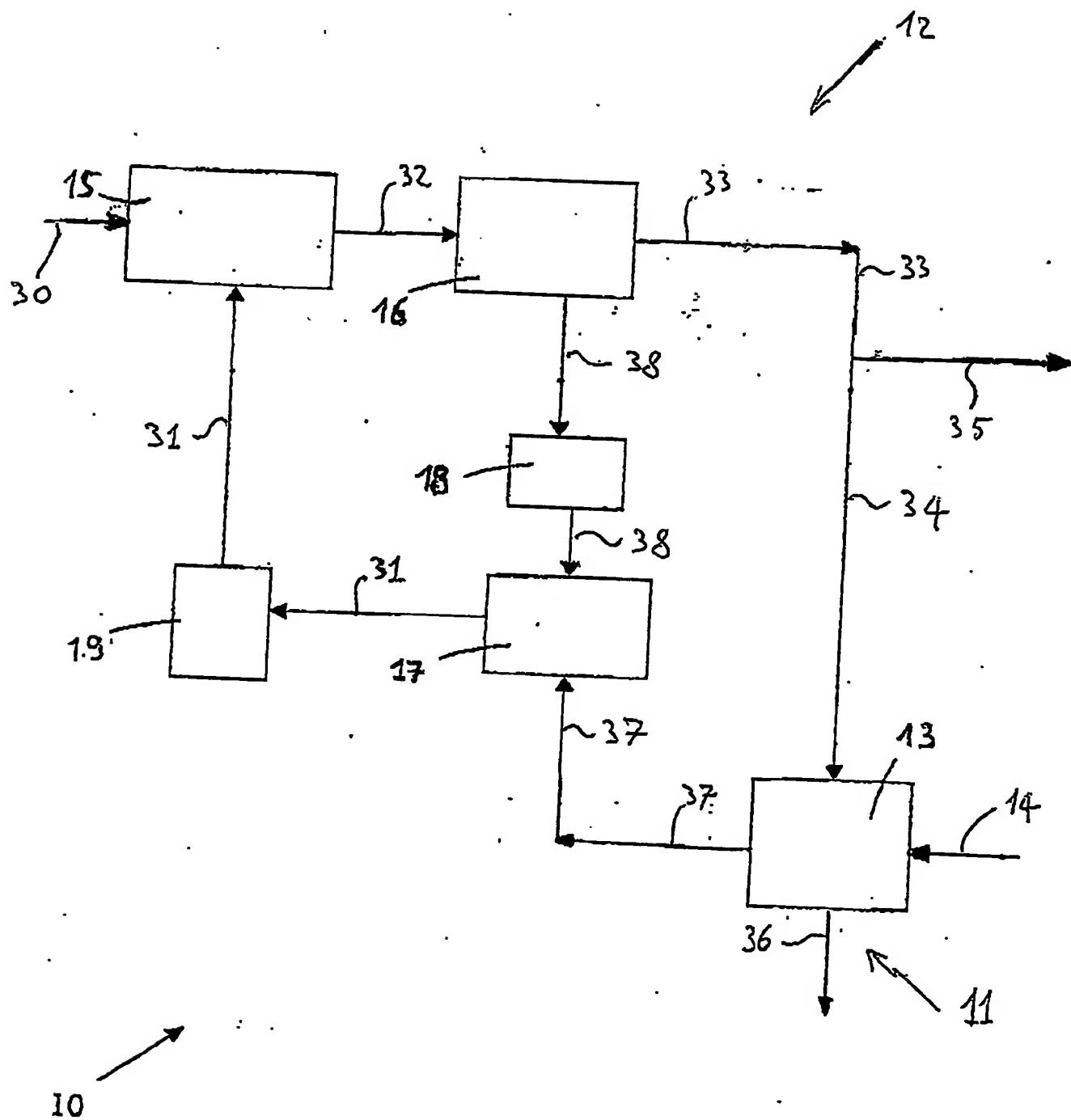


Fig. 1